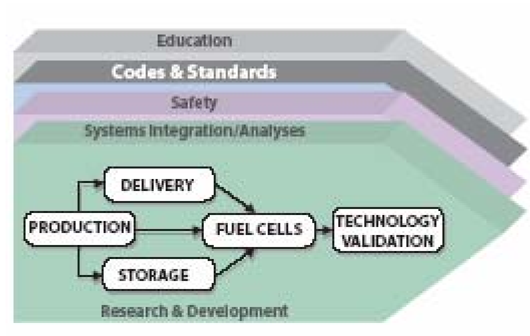
# 3.6 Hydrogen Codes and Standards




The U.S. and most countries in the world have established laws and regulations that require commercial products to meet all applicable codes and standards to demonstrate that they are safe, perform as designed, and are compatible in systems in which they are used. Hydrogen has an established history of industrial use as a chemical feedstock, but its use as an energy carrier on a large-scale commercial basis remains largely untested and undeveloped. The development and promulgation of codes and standards are essential to establish a market-receptive environment for commercial, hydrogen-based products and systems.

**Codes- Model building codes are guidelines for the design of the built environment (e.g. buildings and facilities). Codes are generally adopted by local jurisdictions, thereby achieving a force of law. Codes often refer to or invoke standards for the equipment used within the built environment.**

**Standards - Standards are rules, guidelines, conditions or characteristics for products or related processes, and generally apply to equipment or components. Standards achieve a regulatory-like status when they are referred to in codes or through government regulations.**

DOE's focus is the research and development needed to strengthen the scientific basis for technical requirements incorporated in national and international standards, codes and regulations. DOE is also sponsoring a national effort by industry, standards and model code development organizations, and government to prepare, review and promulgate hydrogen codes and standards needed to expedite hydrogen infrastructure development and to help enable the emergence of hydrogen as a significant energy carrier. In addition, DOE is also supporting the harmonization of essential requirements for the safe use of hydrogen by consumers in the U.S. and through the International Partnership for a Hydrogen Economy (IPHE).

The aim of this Program element is to identify those codes and standards that will be necessary or helpful in the implementation of the hydrogen economy, to facilitate their development, and to support publicly-available research that will be necessary to develop a scientific and technical basis for such codes and standards.

## 3.6.1 Goal and Objectives

### Goal

Perform underlying research to enable codes and standards to be developed for the safe use of hydrogen in all applications. Facilitate the development and harmonization of international codes and standards.

### Objectives

- By 2006, facilitate the adoption of the most recently available model codes (e.g., ICC) in key regions; complete research and development on hydrogen release scenarios; and provide a sound basis for model code development and adoption.

- By 2007, support and facilitate the drafting of model building codes for hydrogen applications (i.e., NFPA 5000) by the National Fire Protection Association (NFPA).
- By 2007, support and facilitate the completion of the ISO standards for hydrogen refueling and on-board storage.
- By 2008, support and facilitate the completion of standards for bulk hydrogen storage (e.g., NFPA 55) with experimental data and input from Technology Validation Program element activities.
- By 2010, support and facilitate development of Global Technical Regulations (GTR) for hydrogen vehicle systems under the United Nations Economic Commission for Europe, World Forum for Harmonization of Vehicle Regulations, and Working Party on Pollution and Energy Program (ECE-WP29/GRPE).
- By 2015, complete necessary codes and standards that support the commercialization of hydrogen technologies.

## 3.6.2 Technical Approach

The Hydrogen, Fuel Cells & Infrastructure Technologies Program recognizes that domestic and international codes and standards must be established along with affordable hydrogen and fuel cell technologies to enable the timely commercialization and safe use of hydrogen technologies. The lack of codes and standards applicable to hydrogen as an energy carrier is a major institutional barrier to deploying hydrogen technologies and developing a hydrogen economy. It is in the national interest to eliminate this potential barrier. As such, this Program element works with domestic and international Standard Development Organizations (SDOs) to facilitate the development of performance-based standards. These standards are then referenced by building codes to expedite regulatory approval of hydrogen technologies. This approach ensures that U.S. consumers can purchase products that are safe and reliable, regardless of their country of origin, and that U.S. companies can compete internationally.

The key U.S. and international SDOs developing and publishing the majority of hydrogen codes and standards are shown in Table 3.6.1. These organizations typically work with the public and private sectors to develop codes and standards.

**Table 3.6.1. Organizations Involved in Codes and Standards Development and Publication**

| Organization | Responsibility |
|---|---|
| **Domestic Codes and Standards** | |
| American Society for Testing and Materials (ASTM) | Materials testing standards and protocols |
| American National Standards Institute (ANSI) | Certifies consensus methodology of and serves as clearinghouse for codes and standards development |

| | |
|---|---|
| American Petroleum Institute (API) | Equipment standards |
| American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) | Equipment design and performance standards |
| American Society of Mechanical Engineers (ASME) | Equipment design and performance standards |
| Compressed Gas Association (CGA) | Equipment design and performance standards |
| CSA America (CSA) | Equipment standards |
| International Association of Plumbing and Mechanical Officials (IAPMO) | Mechanical building code |
| Institute of Electrical and Electronic Engineers (IEEE) | Electrical standards |
| International Code Council, Inc. (ICC) | Family of model building codes |
| National Fire Protection Association (NFPA) | Model building codes, standards |
| Natural Gas Institute (NGI) | Natural gas vehicle standards |
| Society of Automotive Engineers (SAE) | Vehicle standards |
| Underwriters Laboratories (UL) | Equipment and performance testing standards |
| **International Codes and Standards** | |
| International Electrotechnical Commission (IEC) | International performance standards |
| International Organization for Standardization (ISO) | International performance standards |

Recently, a national agenda for hydrogen codes and standards has emerged through a collaborative effort among DOE, industry, standards development organizations (SDOs) and model code development organizations (CDOs). This collaboration has enabled significant progress in the development of codes and standards for hydrogen applications. For example, provisions for hydrogen use are included in the International Code Council's (ICC) International Building, Residential, Fire, Mechanical and Fuel Gas model codes. Additional provisions, such as underground storage of liquid hydrogen and canopy storage of gaseous hydrogen, will be incorporated in a future edition of the ICC model codes.

The Codes and Standards Tech Team under the FreedomCAR and Fuel Partnership has developed and maintains an RD&D roadmap to establish a firm scientific and technical basis for codes and standards. The roadmap identifies key experimental and analytical needs to support codes and standards development. Data and information obtained through implementation of the roadmap are provided to the appropriate standards and model code development organization. The Tech Team also reviews the DOE RD&D projects annually so that the results generated effectively support codes and standards development.

### Research to Facilitate Domestic Codes and Standards Development

A primary role of this Program element is to perform R&D that supports the development of hydrogen codes and standards. This R&D focuses on basic hydrogen properties and behavior, as well as the testing of materials and components that support standards development.

In the development of hydrogen codes and standards, the Hydrogen, Fuel Cells & Infrastructure Technologies Program acts as a facilitator in the standards development process and provides funding to support this process. One result of DOE's effort is the creation of "national templates," which identify players and establish relationships to facilitate codes and standards development. Through these relationships, DOE and the major SDOs and CDOs coordinate the preparation of critical standards and codes for hydrogen technologies in vehicular and stationary applications. The structure provided by the templates is implemented through the DOE Hydrogen Codes and Standards Coordinating Committee (HCSCC). The HCSCC provides a forum for the codes and standard community to keep participants aware of progress in implementing the templates and discuss issues and concerns that may arise. It is also important to note that state and local governments must incorporate standards and model codes in regulations for the standards and codes to be enforceable.

The Program is also assuming a communication and education role, so that timely, accurate, and relevant information is prepared and disseminated to stakeholders. An important part of implementing the national templates is to maintain an awareness of the status of and changes in hydrogen code and standards. To this end, DOE maintains a matrix (posted at www.hydrogensafety.info) that lists codes and standards by application area and for each code and standard listed, provides a brief description, technical contacts and current status.

Information about current codes and standards issues is also provided though the Hydrogen Safety Newsletter published monthly by the National Hydrogen Association (NHA) and available at the same Web site as the matrix. DOE has also created an interactive Web site (www.fuelcellstandards.com) that allows searching for information on codes and standards under several search criteria, including application and geographic region. The Web site also tracks activities in codes and standards and provides a convenient site for information on codes and standards. To improve access to current hydrogen codes and standards, the DOE is working with ANSI to create a hydrogen portal on ANSI's national standards network. The portal will provide electronic access to key hydrogen standards and model codes.

The ICC and the NFPA are the two major organizations in the U.S. that develop model codes. Typical model codes available for adoption by state and local governments are listed in Table 3.6.2. Many of these model codes have been or are being amended to incorporate requirements for hydrogen applications.

**Table 3.6.2. Typical Model Codes**

| Model Code | Content |
|---|---|
| Fire Code | Regulations affecting or relating to structures, processes, premises, and safeguards regarding fire and explosions. |
| Building Code | Ensures public health, safety, and welfare as they are affected by repair, alteration, change of occupancy, addition, and location of existing buildings. |
| Electrical Code | Ensures public safety, health, and general welfare through proper electrical installation, including alterations, repairs, replacement, equipment, appliances, fixtures, and appurtenances. |
| Property Maintenance Code | Ensures adequate safety and health as they are affected by existing building structures and premises. |
| Zoning Code | Enforces land use restrictions and implements land use plan. |
| Energy Conservation Code | Ensures adequate practices for appliances, HVAC, insulation, and windows for low cost operation. |
| Residential Code | Applies to the construction, alteration, movement, enlargement, replacement, repair, use, and occupancy of one- and two-family dwellings. |
| Plumbing Code | Regulates the erection, installation, alternation, repairs, relocation, and replacement, in addition to use or maintenance, of plumbing systems. |
| Mechanical Code | Regulates the design, installation, maintenance, alteration, and inspection of mechanical systems that are permanently installed and used to control environmental conditions and related processes. |
| Fuel Gas Code | Regulates the design, installation, maintenance, alteration, and inspection of fuel gas piping systems, fuel gas utilization equipment, and related accessories. |
| Performance Code | Establishes requirements to provide acceptable levels of safety for fire fighters. |

Table 3.6.3 summarizes the various roles that the private sector and federal government have in the development process. The federal government's traditional role has been to serve as a facilitator/developer for standards that cover technologies or applications that are of national interest. Examples include the involvement of the U.S. Coast Guard in standards for marine use; the Department of Transportation (DOT) for interstate pipelines, tunnels, railroads and

interstate highways; and DOE for appliances (e.g. voluntary Energy Star Program). In each case, the private sector plays a significant role in the process.

The federal government also plays an important role in the adoption process, which involves converting a voluntary standard or model code into a law or regulation. Congress may pass laws governing both residential and commercial building design and construction to ensure public safety. Certain agencies of the federal government may also be granted authority by Congress to adopt and implement regulatory programs.

**Table 3.6.3. Private and Federal Sector Role in Codes and Standards Development**

| Private Sector | | Government Sector | | |
|---|---|---|---|---|
| Standard/Model Code Development Organizations | Other Private Sector Firms | Federal | State | Local |
| Develop consensus-based codes and standards with open participation of industry and other stakeholders. | Develop hydrogen technologies and work with SDOs to develop standards. | Perform underlying research to facilitate development of codes and standards, support necessary research and other safety investigations, and communicate relevant information to stakeholders (including state and local government agencies). | Evaluate codes and standards that have been developed and decide whether to adopt in whole, part, or with changes. | Evaluate codes and standards that have been developed and decide whether to adopt in whole, part, or with changes. |

### International Codes and Standards Development

The Hydrogen, Fuel Cells & Infrastructure Technologies Program supports the development of international codes and standards to facilitate trade between the U.S. and other countries. The Program element coordinates and supports the participation of U.S. experts at key international codes and standards development organization meetings sponsored by ISO, IEC and ECE-WP29/GRPE. Through its coordination of the domestic codes and standards agenda, the Program element facilitates national consensus positions on international standards. The Program element also supports and coordinates the U.S. Technical Advisory Groups (TAGs) for ISO TC197 (Hydrogen Technologies) and IEC TC105 (Fuel Cell Technology). The TAGs provide a national forum for industry and government experts to develop consensus positions on proposed ISO and IEC documents and actions. The Program element also works with the EPA and DOT/NHTSA to provide technical expertise on issues before the WP29/GRPE.

## 3.6.3 Programmatic Status

### Current Activities

The current Hydrogen Codes and Standards Program element activities are summarized in Table 3.6.4.

**Table 3.6.4. Ongoing Activities for Hydrogen Codes and Standards**

| Activity | Objective | Organizations |
|---|---|---|
| **U.S. Domestic Codes and Standards Development Activities** | | |
| Stakeholder Meetings and Technical Forums | Supports technical and coordination meetings to ensure communications among key stakeholders. | NREL, PNNL, LANL, SNL, NHA |
| Technical Expertise | Supports hydrogen safety research and provides expert technical representation at key industry forums and codes and standards development meetings, such as the ICC and NFPA model code revision process | SNL, NREL, LANL |
| Consensus Codes and Standards Development | Supports coordinated development of codes and standards through a national consensus process | NREL, SNL, SAE, CSA, NHA, NFPA, ICC, ANSI |
| Information Dissemination | Supports information forums for local chapters of building and fire code officials, and the development of case studies on the permitting of hydrogen refueling stations. | PNNL, NHA |
| Research, Testing, and Certification | Supports focused research and testing needed to verify the technical basis for hydrogen codes and standards and for certification of components and equipment. | SNL, NREL |
| Training Modules and Informational Videos | Supports the development of mixed media training modules and informational videos for local code officials, fire marshals, and other fire and safety professionals. | PNNL |
| National Template for Standards, Codes, and Regulations | Identifies key areas of standards, codes, and regulations for hydrogen vehicles and hydrogen fueling/service/parking facilities and designates lead and supporting organizations. | NREL |
| Codes and Standards Matrix Database | Provides inventory and tracking of relevant domestic codes and standards: identifies gaps, minimizes overlap, and ensures that a complete set of necessary standards is written. | NREL, ANSI |

| U.S. International Codes and Standards Development Activities | | |
|---|---|---|
| International Stakeholder, Consensus Development, and Harmonization Meetings | Supports the international codes and standards development activities of ISO TC197, IEC TC105, and the International Partnership for a Hydrogen Economy (IPHE) | LANL, NREL |
| Technical Expertise and Underlying Research Activities | Provides representation and technical expertise in support of U.S. concerns at key international codes and standards development organization meetings and forums, including ISO, IEC, and United Nations Economic Commission for Europe (WP29/GRPE). | LANL, NREL, SNL |

## Status of Equipment Standards

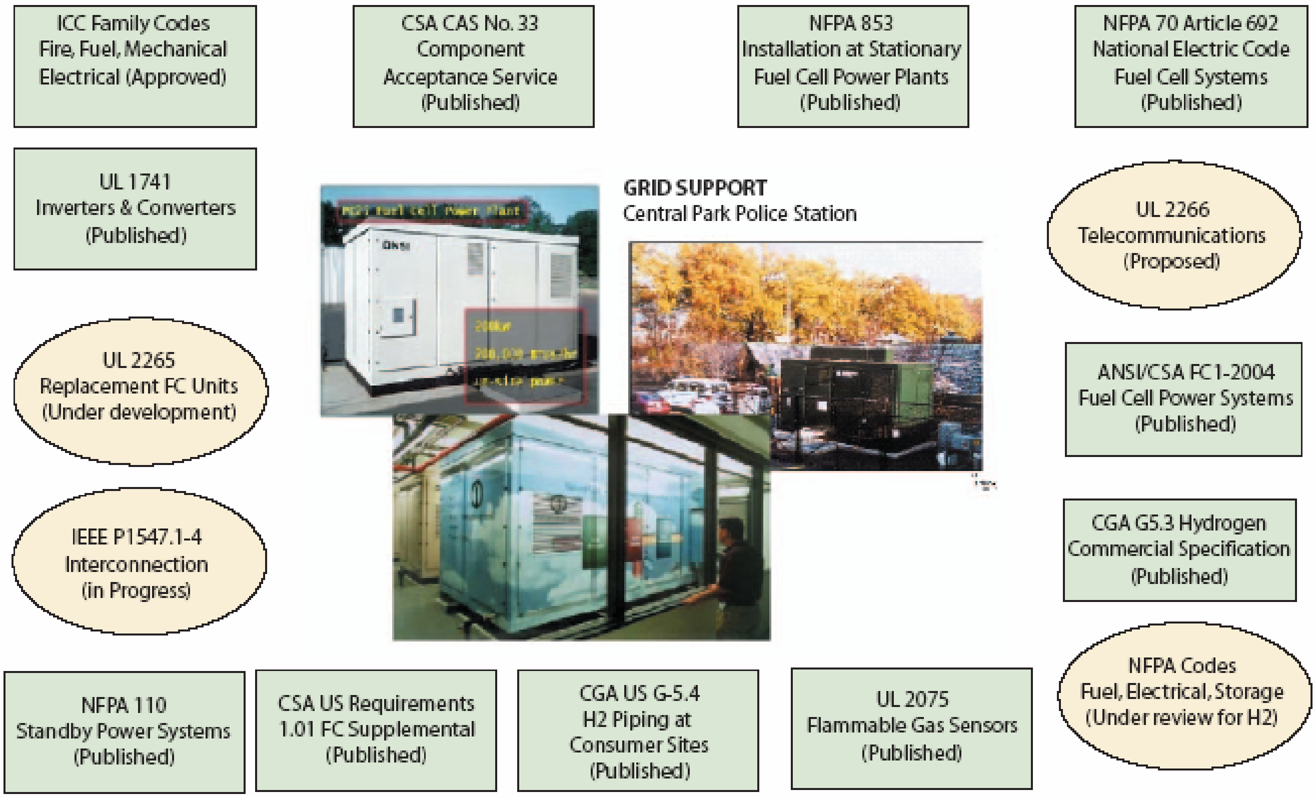
### Domestic Standards

The status of domestic standards in each application area is described below.  Up to date information on the development of fuel cell equipment standards is maintained at www.fuelcellstandards.com.

### Stationary Fuel Cell Standards

Stationary fuel cell standards are the most comprehensively available standards within hydrogen technologies, as the phosphoric acid fuel cell has been commercially available for more than 20 years.  Standards are being revised or developed to more adequately represent emerging fuel cell technologies. Figure 3.6.1 illustrates the significant efforts underway for standards development related to stationary fuel cells.

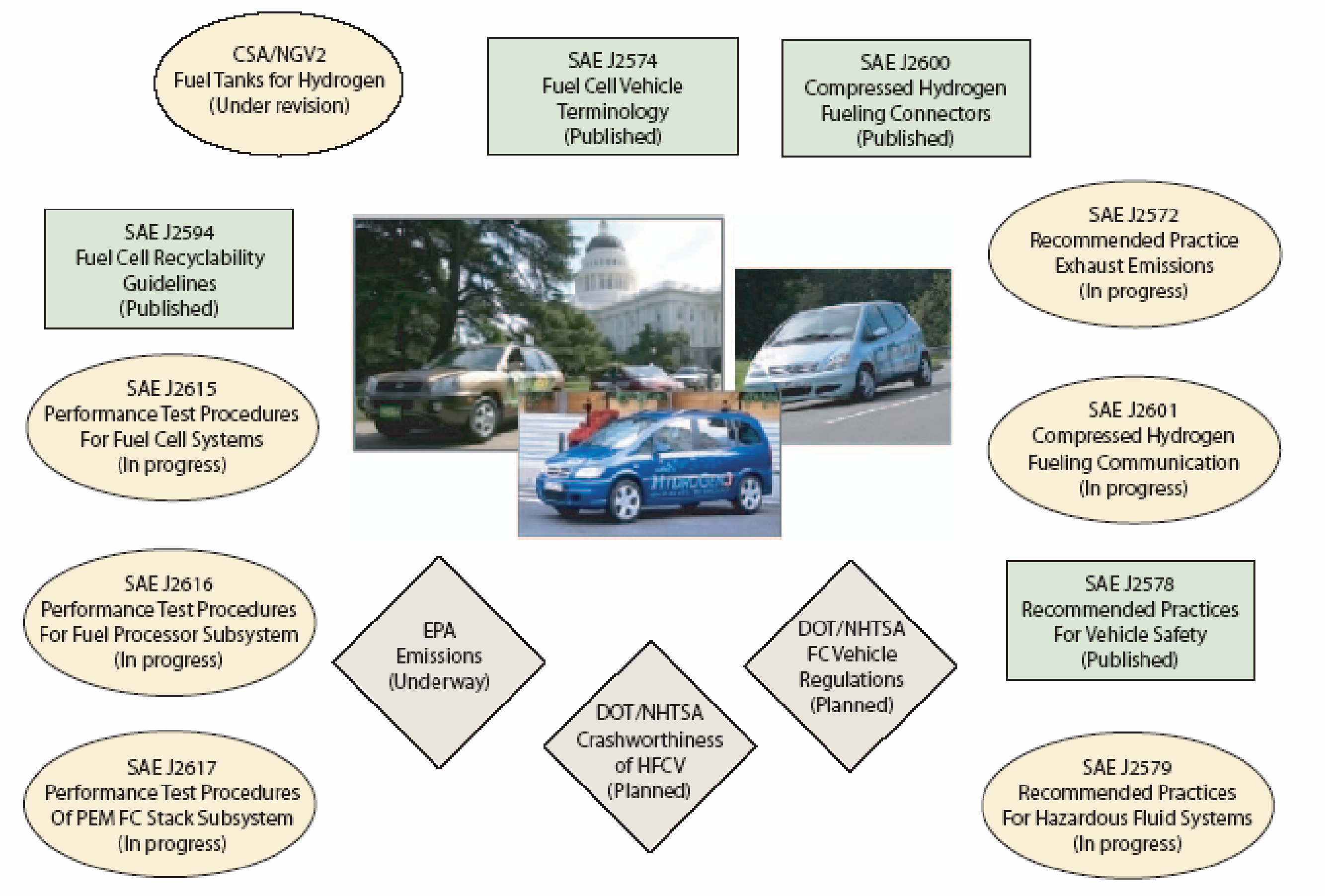
Figure 3.6.1. Domestic Codes and Standards for Stationary Fuel Cells




**Fuel Cell Vehicle Standards**

A comprehensive effort is underway for the development of standards for automotive technologies. SAE, working with technical experts from automotive, industrial gas and fuel cell companies, has developed a list of the standards that are needed for the commercialization of fuel cell vehicles. Figure 3.6.2 shows the standards under development for fuel cell vehicle applications.

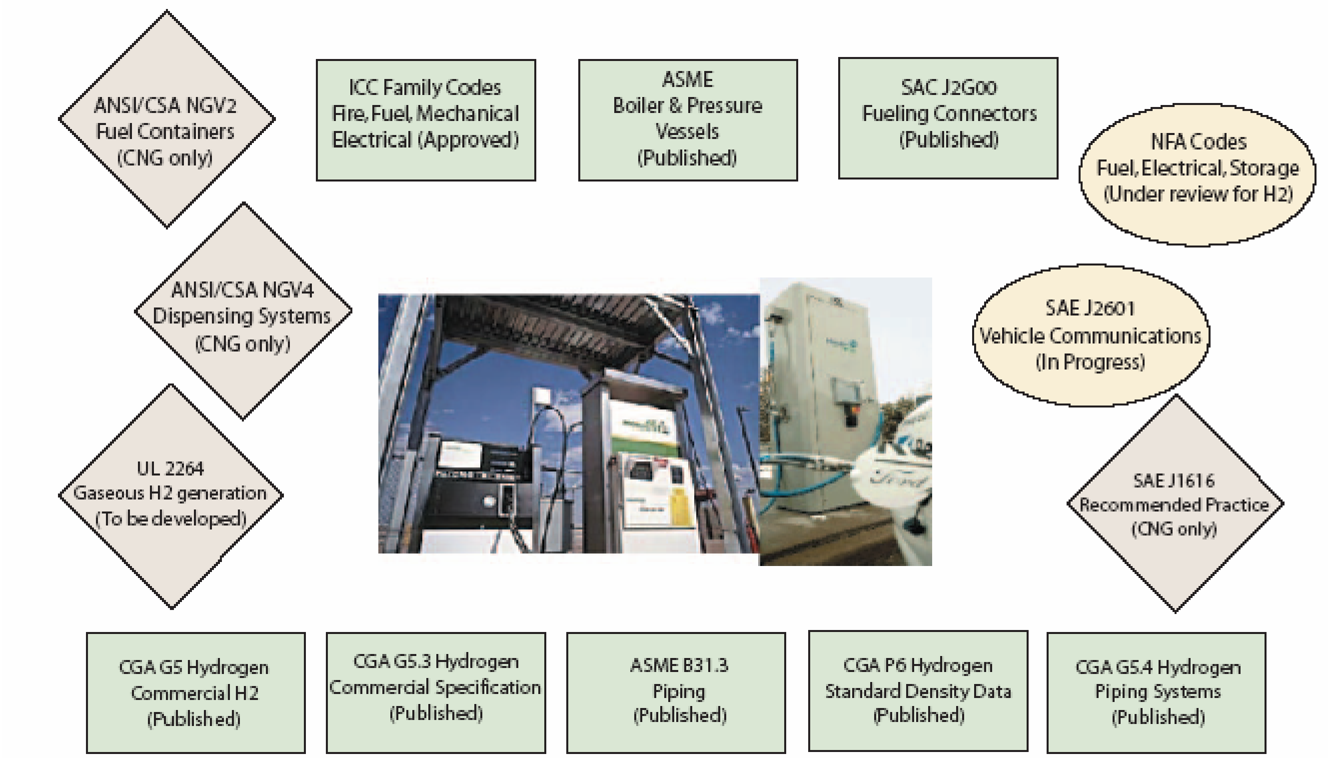
Figure 3.6.2. Domestic Codes and Standards for Hydrogen-fueled Vehicles




**Refueling Station Standards**

The development of standards for hydrogen fueling stations is underway. Although standards have been developed for commercial production, delivery and use of hydrogen, these industry-based design requirements and standard operating procedures are not suitable for dealing with hydrogen in a consumer environment. Efforts are focused on developing new standards, or clarifying the language or constraints in established standards to account for the significant differences in hazards and risks. Figure 3.6.3 shows the standards development efforts for fueling stations. In all cases, safety is ensured through comprehensive engineering reviews, hazard evaluations and risk mitigation plans.

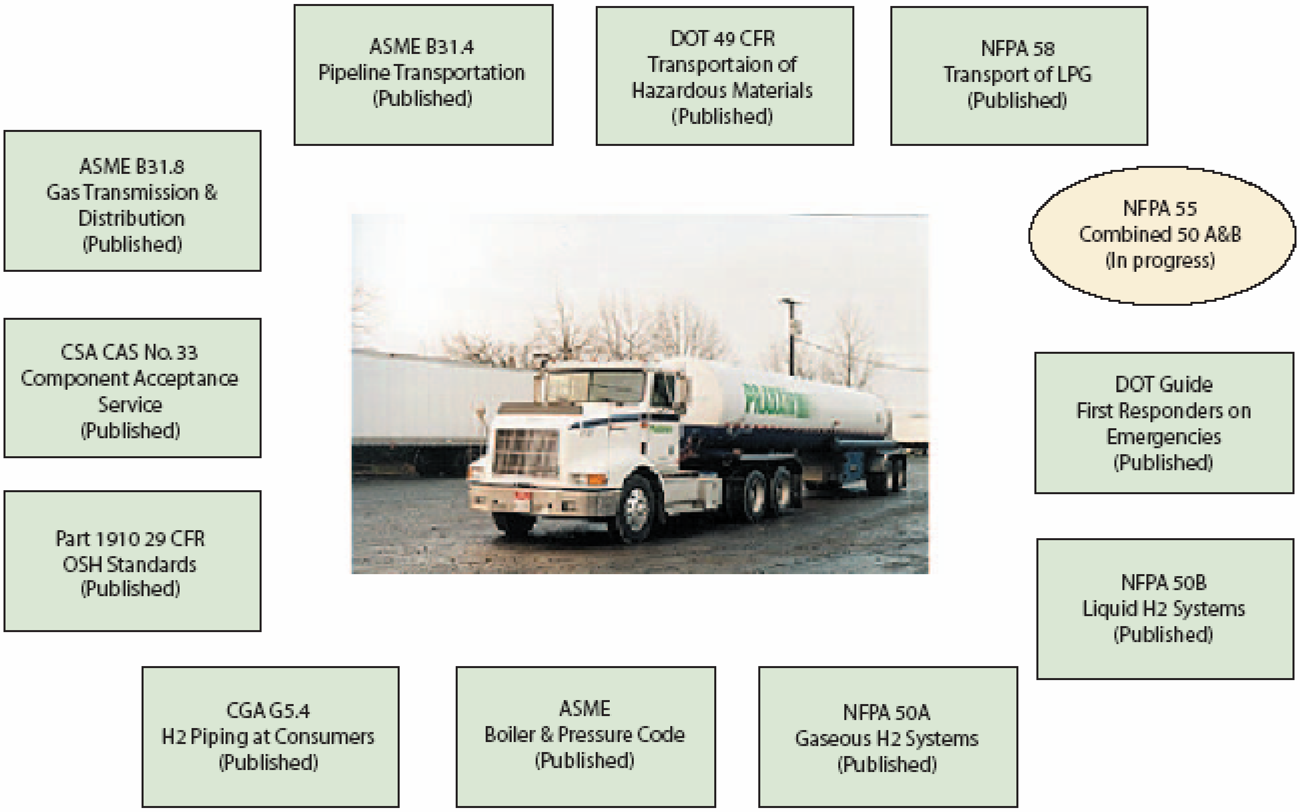
Figure 3.6.3. Status of Domestic Codes and Standards for Hydrogen Fueling Stations




**Hydrogen Transportation Standards**

Since the 1950s, hydrogen has been transported across the U.S. using DOT federal regulations for the safe transport of hydrogen in bulk and small portable containers. An effort is underway to update these standards to address the range of technologies now available. Figure 3.6.4 illustrates the satus of standards for the transport of hydrogen.

Figure 3.6.4. Domestic Codes and Standards for Hydrogen Transport




## International Standards

Three separate but related international efforts are underway to develop new technology standards through the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC) and the World Forum for Harmonization of Vehicle Regulations.

### *International Organization for Standardization*

ISO is a worldwide federation of national standards bodies from more than 140 countries. Established in 1947, its mission is to promote standardization to facilitate the exchange of goods and services, and to facilitate cooperation in intellectual, scientific, technological and economic activities. ISO standards are developed through a consensus process.

The following ISO Technical Committees are working on standards related to hydrogen and fuel cells:

- **TC 22 - Road Vehicles:** compatibility, interchangeability, and safety, with particular attention to terminology and test procedures for mopeds, motorcycles, motor vehicles, trailers, semi-trailers, light trailers, combination vehicles, and articulated vehicles. The Electric Road Vehicle Subcommittee (SC21) is addressing operation of vehicles, safety, and energy storage.

- **TC 197 - Hydrogen Technologies:** systems and devices for the production, storage, transport, measurement, and use of hydrogen. Working groups address standards for gaseous and liquid fuel tanks for vehicles, multimodal transport of liquid hydrogen, airport refueling facility, hydrogen safety, hydrogen and hydrogen blends, hydrogen fuel quality, water electrolysis, fuel processing, and transportable gas storage devices.
- **TC 58 - Gas Cylinders:** fittings and characteristics related to the use and manufacture of high-pressure gas storage. The working group on gas compatibility and materials coordinates with TC 197.

***International Electrotechnical Commission***

IEC is a leading global organization for preparing and publishing international standards for electrical, electronic and related technologies. The IEC is developing standards for the electrical interface to fuel cells. IEC Technical Committee 105 is primarily addressing stationary fuel cell power plants, but has also addressed portable and propulsion fuel cells. The working groups in TC 105 include: Terminology, Fuel Cell Modules, Stationary Safety, Performance, Installation, Propulsion, and Safety and Performance of Portable Fuel Cells.

***World Forum for Harmonization of Vehicle Regulations***

Within the U.N. framework on GRPE, the European Union recognized a need to harmonize vehicle regulations. The original agreement was signed in 1958, with contracting parties including most European countries, Australia, Japan and South Africa, but not the United States. Contracting parties have two years to adopt standards developed under the 1958 agreement. Requirements ("regulations" or "directives") under this agreement are based on the "type" approval process, wherein an authority works with a technical service to assess compliance of components and systems (such as a vehicle). European countries use the "type" approval process, while the U.S. uses a self-certification process.

Since the initial agreement, the ECE WP29 developed a new "accelerated" agreement to allow the development of global legal requirements. The 1998 agreement has most European countries, Canada, China, Japan, Korea, South Africa and the U.S. as contracting parties. This new concept is termed Global Technical Regulations (GTR). These regulations are essentially technical requirements; therefore, they allow the use of different approval processes and global harmonization of legal requirements for all vehicles. The GRPE established an Ad Hoc Group to draft regulations for gaseous and liquid hydrogen systems. The ISO process and that instituted by the GRPE will harmonize the differences between both standards. In June 2002, the GRPE voted to move all actions for the introduction of fuel cell vehicles under the 1998 agreement to accelerate the development and adoption of a GTR. This Program element will monitor and participate in this process in support of the EPA and DOT/NHTSA lead responsibilities.

## 3.6.4 Challenges

A major challenge to the commercialization of hydrogen technologies is the lack of available data necessary to develop and validate standards. The Program sponsors a comprehensive, long-term RD&D effort to develop the scientific and technical basis for requirements incorporated in standards and model codes.

Another challenge to the commercialization of hydrogen technologies is the availability of appropriate codes and standards to ensure consistency and, if possible, uniformity of requirements and facilitate deployment. Certification to applicable standards facilitates approval by local code officials and safety inspectors. Uniform standards are needed because manufacturers cannot cost-effectively manufacture multiple products that would be required to meet different and inconsistent standards.

Domestically, competition between the individual SDOs could impact the adoption of new codes for hydrogen and fuel cell technologies. Because of the typical three- to five-year development cycle, some demonstration projects could be delayed or incur additional development costs. The DOE has worked with SDOs, CDOs and industry to minimize duplication in domestic codes and standards development. International standards developed by ISO and IEC will have an increasing impact on U.S. hydrogen and fuel cell interests. The U.S., Japan and Europe, among others, have accelerated efforts in this area, and the Program supports cooperative and coordinated development of international standards.

### 3.6.4.1 Targets

Since the development of the model codes or domestic and international standards is a voluntary, industry-led process, the federal government can influence but cannot direct this process. The Codes and Standards Program element activities will focus on assisting the commercial acceptance of hydrogen and fuel cell technologies.

Working with state and local code officials, the Hydrogen, Fuel Cells & Infrastructure Technologies Program will develop training programs to explain the new technologies, provide case studies of installations and operation, and communicate the changes in the codes as they pertain to the new technology. The Codes and Standards Program element will also work with state and local government officials to assist in the adoption of approved model codes through education and outreach in cooperation with the Education Program element (deferred).

This Program element will provide expertise and technical data on hydrogen properties, and hydrogen and fuel cell technologies to facilitate the development of standards and codes. Additionally, the Program element will provide support for industry and laboratory experts to participate in critical international standards development meetings and workshops.

The Program element will continue to work directly with the SDOs, by providing technical support to facilitate identification and development of new standards for hydrogen technologies, fuel cell systems and system monitoring and safety. Table 3.6.5 lists the high priority items for the Codes and Standards Program element.

Finally, this Program element supports focused research for testing and certifying hydrogen components and equipment.

**Table 3.6.5. High Priorities for Development**

| Items | Content |
|---|---|
| Piping (Non-transport) | Hydrogen-specific piping design, installation, and certification standards. |
| Storage | Hydrogen storage tank standards for portable, stationary and vehicular use. |
| Materials Guide | Materials reference guide for design and installation. |
| Hydrogen Quality | Hydrogen specifications and testing methods. |
| Mass Measurement | Methods to quantify hydrogen mass measurement to determine appliance efficiency and consumer sales at refueling stations. |
| Transport | Standards for pipelines, delivery and ancillary equipment. |

## 3.6.4.2 Barriers

The barriers are summarized below.

**A. Limited Government Influence on Model Codes.** The code development process is voluntary, so the government can affect its progression, but buy-in is ultimately required from code publishing groups.

**B. Competition between SDOs and CDOs.** The competition between various organizations hinders the creation of consistent hydrogen codes and standards.

**C. Limited State Funds for New Codes.** Budgetary shortfalls in many states and local jurisdictions impact the adoption of codes and standards, since they do not always have the funds for purchasing new codes or for training building and fire officials.

**D. Large Number of Local Government Jurisdictions (approximately 44,000).** The large number of jurisdictions hinders the universal adoption of codes and standards.

**E. Lack of Consistency in Training of Officials**. The training of code officials is not mandated and varies significantly. There are a large number of jurisdictions and variation in training facilities and requirements.

**F. Limited DOE Role in the Development of International Standards.** Governments can participate and influence the development of codes and standards, but they cannot direct the development of international standards.

**G. Inadequate Representation at International Forums.** Participation in international forums and meetings is voluntary and, to date, has been ad hoc rather than planned and coordinated in advance.

**H. International Competitiveness.** Economic competition complicates development of international standards.

**I. Conflicts between Domestic and International Standards.** National positions can complicate the harmonization of domestic and international standards.

**J. Lack of National Consensus on Codes and Standards.** Competitive issues hinder consensus.

**K. Lack of Sustained Domestic Industry Support at International Technical Committees**. Cost, time and availability of domestic hydrogen experts has limited consistent support of the activities conducted within the international technical committees.

**L. Competitiveness in Sales of Published Standards.** The development and licensing of codes and standards is a business, and the competitiveness associated with the adoption of one set of codes and standards inhibits harmonization.

**M. Jurisdictional Legacy Issues.** NFPA codes are historically adopted by some states and local jurisdictions; others accept the ICC codes. Jurisdictions that adhere to a specific code family may not reference the most recent codes and standards available.

**N. Insufficient Technical Data to Revise Standards.** Research activities are underway to develop and verify the technical data needed to support codes and standards development, retrofitting existing infrastructure and universal parking certification, but are not yet completed.

**O. Affordable Insurance is Not Available.** New technologies not yet recognized in codes and standards will have difficulty in obtaining reasonable insurance.

**P. Large Footprint Requirements for Hydrogen Fueling Stations.** The existing set-back and other safety requirements result in large footprints.

**Q. Parking and Other Access Restrictions.** Complete access to parking, tunnels and other travel areas has not yet been secured.

## 3.6.5 Task Descriptions

Task descriptions for the Hydrogen Codes and Standards Program element are presented in Table 3.6.7. To complete these tasks, this Program element will collect and analyze data from the Production, Delivery, Storage, Fuel Cells, Education (deferred) and Technology Validation subprograms on an on-going basis.

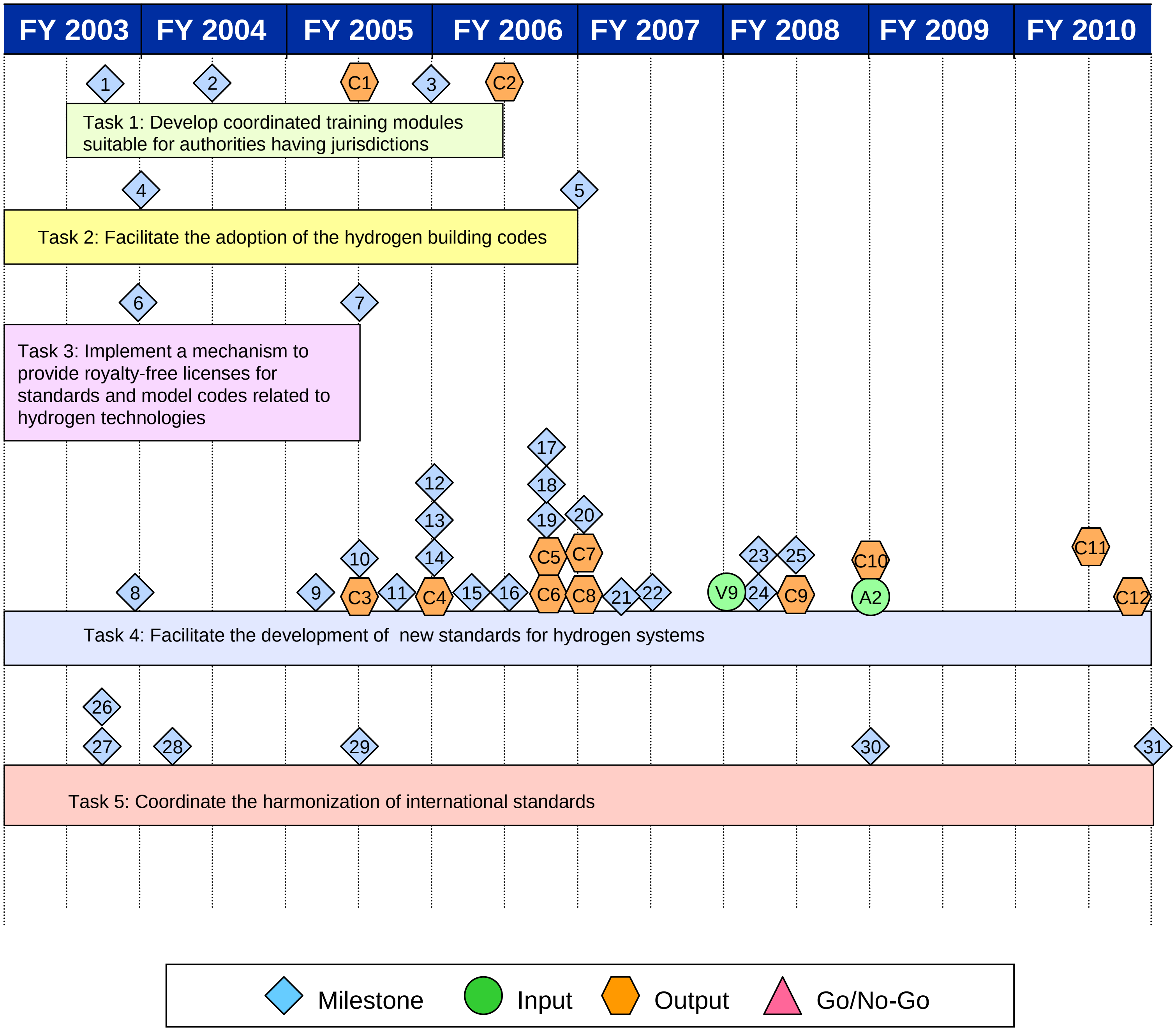
**Table 3.6.7. Task Descriptions**

| | Description | Barriers |
|---|---|---|
| *1* | Develop coordinated training modules suitable for authorities having jurisdiction | C, D, E |
| *2* | Perform R&D of hydrogen properties and behavior and coordinate participating organizations to facilitate the adoption of the hydrogen building codes | C, D |
| *3* | Implement a mechanism to provide royalty-free licenses for standards and model codes related to hydrogen technologies | A, B |
| *4* | Perform component R&D and integrated systems analysis to support the development of new standards for hydrogen systems | F, G, H, I, J, K, M, N, O, P, Q |
| *5* | Coordinate the harmonization of international standards<br>• Facilitate the development of U.S. consensus for international standards<br>• Facilitate unified approach to standards development among key countries in<br>• Europe and the Pacific Rim<br>• Develop mechanism to license ISO standards | F, G, H, I, J, L |

## 3.6.6 Milestones

Figure 3.6.5 shows the interrelationship of milestones, tasks, supporting inputs and outputs from other Program elements from FY 2004 through FY 2010. This information is also summarized in Appendix B.

# Hydrogen Codes & Standards R&D Milestone Chart



**Milestones**

1 Produce a curriculum for training modules.
2 Collaborate with ICC and NFPA to develop first- order continuing education for code officials.
3 Coordination plan with Education Program element for state and local official training established.
4 Coordination Committee for hydrogen technical experts to support the code development process established.
5 Complete analytical experiments and data collection for hydrogen release scenarios as needed to support code development (Phase 1).
6 Generic licensing agreement drafted and estimated licensing costs established.
7 Final generic licensing agreement, schedule of critical licensing agreements, and budget requirements developed for FY05 and beyond.
8 Workshop to identify and develop critical research objectives that impact model codes held.
9 Initiate experimental validation of large hydrogen releases and jet flame tests completed.
10 Final code changes that incorporate underground storage of liquid hydrogen and canopy-top storage of gaseous hydrogen for fueling stations (NFPC, ICC) completed.
11 Perform tests of walled hydrogen storage systems.
12 Complete detailed scenario analysis risk assessments.
13 Draft standards for dispensing systems (dispenser, hoses, hose assemblies, temperature compensating devices, breakaway devices, etc.) available (CSA America).
14 Draft standards for compressed gaseous on-board storage available (CSA HGV-2).
15 Draft standards for sensors and leak detection equipment developed (UL).
16 Draft standards for portable fuel cells completed (UL).
17 Develop small leak characterization for building releases and pressure release devices (PRD).
18 Technical assessment of metallic and composite bulk storage containers completed (ASME).
19 Draft standards for refueling stations completed (NFPA).
20 Implement research program to support new technical committees for the key standards including fueling interface, and fuel storage.
21 Templates of commercially viable footprints for fueling stations that incorporate advanced technologies developed.
22 Complete Model unintended release in complex metal hydrides.
23 Final draft standard (balloting) for sensors and leak detection equipment developed (UL).
24 Final draft standards completed for transportable composite containers for balloting (ASME).
25 Materials compatibility technical reference updated.
26 Negotiate agreement with DOT/NHTSA at Working Party on Pollution and Energy meeting.
27 Mechanism to support appropriate U.S. Technical Advisory Groups (TAG) through CSA America and CGA in place.
28 Initiate the development of the next generation Sourcebook to include Japan, Europe, Canada & U.S. (PATH).
29 Roadmap for global technical regulations (GTR) published.
30 General licensing agreement for ISO standards in place.
31 Draft regulation for comprehensive hydrogen fuel cell vehicle requirements as a GTR approved (UN Global Technical Regulation).

**Outputs**

**C1 Output to Education: Training modules for current practices.**
**C2 Output to Education: Training modules for amended practices for new technologies.**
**C3 Output to Production and Delivery: Preliminary Assessment of Safety, Codes and Standards requirements for the hydrogen delivery infrastructure.**
**C4 Output to Storage: Standards for compressed gaseous on-board storage.**
**C5 Output to Program: Completed hydrogen fuel quality standard as ISO Technical Specification.**
**C6 Output to Delivery, Storage and Technology Validation: Technical assessment of Standards requirements for metallic and composite bulk storage tanks.**
**C7 Output to Delivery, Storage and Technology Validation: Final standards (balloting) for fuel dispensing systems (CSA America).**
**C8 Output to Technical Validation and Delivery: Draft standards (balloting) for refueling stations (NFPA).**
**C9 Output to Delivery and Storage: Materials compatibility technical reference.**
**C10 Output to Fuel Cells: Final draft standard (balloting) for portable fuel cells (UL).**
**C11 Output to Delivery: Codes and Standards for delivery infrastructure complete.**
**C12 Output to Program: Final hydrogen fuel quality standard as ISO Standard.**

**Inputs**

**V9 Input from Technology Validation: Submit final report on safety and O&M of three refueling stations.**
**A2 Input from Analysis: Initial recommended hydrogen quality at each point in the system.**